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Assessment of Lead and Cadmium Contents of Tomatoes and Beans Grown in the Vicinity of Highway of Tokat, Turkey

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Lead and cadmium pollution is a major environmental problem, especially around the highways with high traffic density. When plants grow near highways, they can absorb or accumulate high levels of Pb and Cd in their tissues. This study was conducted to determine Pb and Cd contents in soil and in vegetables grown in the vicinity of highways. Concentrations of Pb and Cd were determined using ICP in tomato and bean (fruit and leaves), which are predominant crops in the region, as well as in soil. Average concentrations of Pb and Cd in tomato, bean and soil were 0.54 and 0.21 mg kg^{-1}, 0.45 and 0.13 mg kg^{-1} and 5.69 and 0.41 mg kg^{-1} respectively. Pb and Cd concentrations were highest in soil followed by leaves and fruits. There was no clear correlation between the level of metals and distance from highway. It might be speculated that wind direction affects the distribution and accumulation of Pb and Cd throughout the research area.

Key Words: Tomato, Bean, Heavy metal pollution, Cadmium, Lead.

INTRODUCTION

Environmental pollution is a significant issue for agricultural activities. Now-a-days, safe agricultural production is common sense for consumers. Vegetables are an important part of human nutrition due to providing various fundamental elements to human uptake[1]. Lead and cadmium, which are highly toxic elements to human body, especially accumulate in soils near highways. According to Bowen[2], elements such as As(III), Al, B, Be, Cd, Co, Cr(IV), Cu, Mo, Ni, Se(IV) and Ti, even in low concentrations, can be harmful to plants and humans.

Anthropogenic accumulation of Pb and Cd in soil also causes increases of concentration of these elements in plant tissues[3–6]. Major sources of lead include

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mining and smelting of metalliferous ores, wastes of industrial origins, disposal of municipal sewage (contained Pb) and burning of leaded gasoline[7]. Another major lead contamination source is car exhaust and coal combustion *via* atmospheric deposition[8]. On the other hand, the major source of cadmium is waste incineration[9]. Actually, heavy metals accumulate in soil and plants in the vicinity of highways due to vehicle corrosion and exhaust gases[10].

Many studies covered heavy metal content in air-water-plant system or soil-plant system. Haiyan and Sautanes[5] reported several studies focused on heavy metal content in soil-plant systems. Some other studies sampled wholesale market products in Australia[11], Bangladesh[12, 13], France[14], Germany[15], Latvia[16], Norway[17] and Poland[18] for some heavy metal concentrations.

Safe agricultural production is a popular concern especially in well developed countries. European Union imports many agricultural items such as vegetables, fruits, etc. from developing countries. Turkey has a great export potential for agricultural products. In addition, Turkey has large areas for agricultural activities including organic farming. From this point of view, soil quality becomes an important issue for safe agricultural production.

The goals of this study were (1) to assess lead and cadmium elements of tomato and bean (fruit and leaves) grown near highways and (2) to address the reason of the accumulation of lead and cadmium in plant and soil.

EXPERIMENTAL

Sample collection: 45 different specimens of tomato and bean (fruit and leaves) were collected from both sites of two state roads. The samples were collected in Kazova and Gözova areas in Tokat, located in northeast of Turkey. Distance from highway was determined using GPS.

Sample preparation: The different vegetable samples were washed with distilled water, cut into parts and dried in electrical furnace at 105°C until well dried. After drying the vegetables were powdered in a mortar and kept in clean polyethylene bags in a desiccator until analysis.

The soil samples were placed in plastic bags and securely tied. Any visible plant and animal residues were removed from samples in the laboratory. Routinely, samples for the same physical and chemical analysis were sieved to pass 2 mm.

Sample preparation for lead and cadmium extracts: 0.3 g of each vegetable sample was digested using 10 mL of concentrated H_2SO_4 in a hot plate. H_2O_2 was added and the samples were then heated until a clear solution was reached. The same procedure was repeated several times. The samples were filtered and diluted to 50 mL using distilled water.

0.5 g of each soil sample was digested using 5 mL of H_2O_2 in a hot plate. The same procedure was repeated until all organic matter was removed. After that, the soil samples were digested with 10 mL HCl/HNO_3 (3 : 1) acid mixture by adding the acid mixture several times. The samples were filtered and diluted to 100 mL using distilled water.

Traffic density: According to the annual Turkish General Directorate of Highways report (2003), average vehicles per day in the two different areas (Kazova and Gözova) were 3343 and 1679 vehicles, respectively[19].

RESULTS AND DISCUSSION

Lead and cadmium concentrations in fruits and leaves of tomato and bean grown in Kazova and Gözova as well as in soils are given in Table-1. It can be seen that the highest accumulations were in soil followed by leaves and fruits.

Lead concentrations in fruit and leaves of tomato were 0.42 and 0.65 mg kg^{-1} while in those of beans were 0.38 and 0.52 mg kg^{-1}. Lead concentrations in soils on which tomato and bean were grown were 5.98 and 5.40 mg kg^{-1}, respectively. Cadmium concentrations in fruit and leaves of tomato were 0.13 and 0.29 mg kg^{-1} while in those of beans were 0.07 and 0.18 mg kg^{-1}. Lead concentrations in soils on which tomato and bean were grown were 0.42 and 0.40 mg kg^{-1}, respectively.

In Kazova, Pb accumulations in bean were higher than tomato while Cd accumulations in tomato were higher than bean. On the other hand, Pb and Cd accumulations were higher in tomato in Gözova. Considering the average accumulation of Pb and Cd in fruit, leaves and soil, Pb accumulation was higher in Gözova while Cd accumulation was higher in Kazova.

TABLE-1
CONCENTRATION OF LEAD AND CADMIUM IN KAZOVA AND GÖZOVA REGIONS

		Kazova		Gözova		Mean	
		Tomato	Bean	Tomato	Bean	Tomato	Bean
Pb	Fruit	0.20 ± 0.03	0.40 ± 0.09	0.64 ± 0.11	0.35 ± 0.08	0.42	0.38
	Leaf	0.40 ± 0.08	0.62 ± 0.08	0.90 ± 0.06	0.42 ± 0.07	0.65	0.52
	Soil	5.39 ± 0.26	5.36 ± 0.26	6.57 ± 1.15	5.44 ± 1.04	5.98	5.40
Cd	Fruit	0.12 ± 0.01	0.03 ± 0.00	0.14 ± 0.03	0.11 ± 0.03	0.13	0.07
	Leaf	0.31 ± 0.03	0.18 ± 0.01	0.27 ± 0.02	0.17 ± 0.01	0.29	0.18
	Soil	0.45 ± 0.02	0.43 ± 0.02	0.38 ± 0.03	0.37 ± 0.02	0.42	0.40
Mean	Pb	2.00	2.13	2.70	2.07		
	Cd	0.29	0.21	0.26	0.22		
Mean	Pb	2.07		2.39			
	Cd	0.25		0.24			

Correlation coefficients calculated among distance from highway and accumulations in fruit, leaves and soil are given in Table-2. In general, there were no meaningful associations between Pb and Cd concentrations in soils and concentrations in fruits or leaves. The relationships were either absent or both positive and negative, *i.e.*, inconsistent, based upon the region, vegetable or heavy metal. It cannot be said that there was a clear decrease in Pb and Cd accumulations in soils, fruits and leaves as the distance from the highway increases.

TABLE-2
CORRELATION AMONG DISTANCE FROM HIGHWAY AND ACCUMULATIONS IN FRUIT, LEAVES AND SOIL

			Kazova			Gözova		
			Fruit	Leaf	Soil	Fruit	Leaf	Soil
Pb	Tomato	Distance	NS	*(+)	V	V	*(–)	*(+)
		Fruit	—	NS	NS	—	*(+)	NS
		Leaf	—	—	*(–)	—	—	NS
	Bean	Distance	NS	NS	NS	NS	NS	NS
		Fruit	—	†(+)	†(–)	—	†(+)	NS
		Leaf	—	—	*(–)	—	—	NS
Cd	Tomato	Distance	NS	NS	NS	NS	NS	NS
		Fruit	—	NS	*(+)	—	*(–)	†(+)
		Leaf	—	—	NS	—	—	NS
	Bean	Distance	NS	NS	NS	†(+)	NS	NS
		Fruit	—	NS	*(–)	—	*(–)	†(+)
		Leaf	—	—	NS	—	—	†(–)

NS: Not significant; * $P < 0.05$; † $P < 0.01$; (+) Positive correlation; (–) Negative correlation.

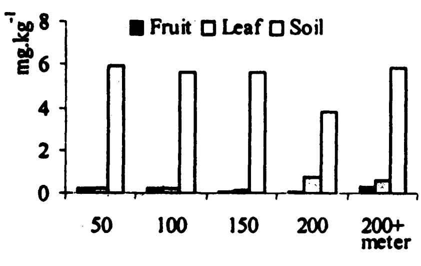

Fig. 1. Pb concentratin of tomato in Kazova

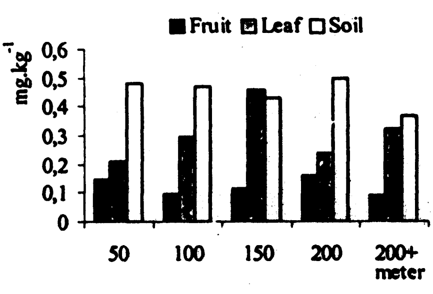

Fig. 2. Cd concentratin of tomato in Kazova

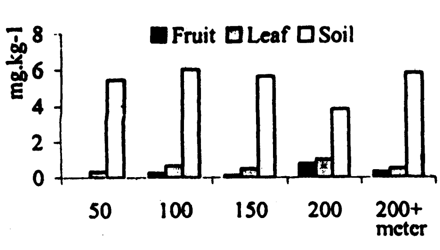

Fig. 3. Pb concentratin of bean in Kazova

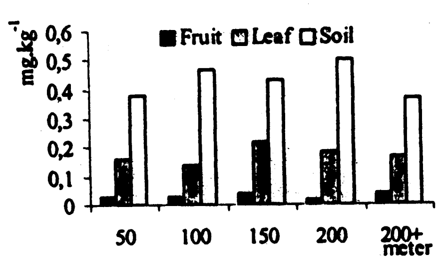

Fig. 4. Cd concentratin of bean in Kazova

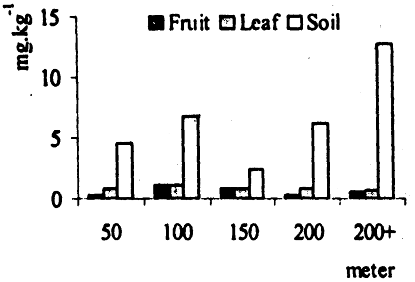

Fig. 5. Pb concentratin of tomato in Gözova

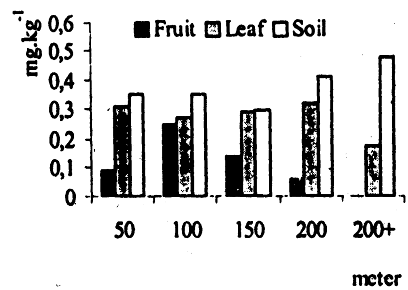

Fig. 6. Cd concentratin of tomato in Gözova

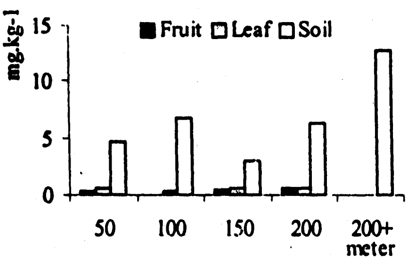

Fig. 7. Pb concentratin of bean in Gözova

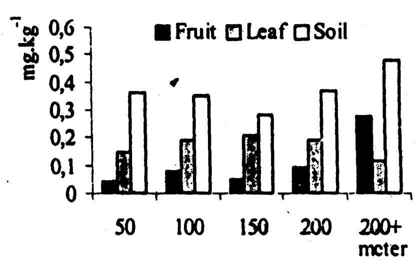

Fig. 8. Cd concentratin of bean in Gözova

De Pier *et al.*[4], found that Cd and Pb contents in potato, cabbage, cauliflower, carrot, turnip, corn and lettuce were 0.03–0.174 and 0.03–0.16 $\mu g\ g^{-1}$ respectively; they also found that Pb and Cd concentration in soil were of 4.9–26.4 and 0.17-1.02 $\mu g\ g^{-1}$ respectively. Romic and Romic[20] found that the Pb and Cd concentrations of topsoil in an urban area were 1.50–139.00 and 0.25–3.85 $\mu g\ g^{-1}$. Haiyan and Stuanes[5] found Cd and Pb levels to be 0.25–14.60 and 25.6–536.1 $\mu g\ g^{-1}$ respectively.

According to Levy *et al.*[21], common ranges for Pb and Cd in plants are 0.5–10.0 and 0.05–2.0 $\mu g\ g^{-1}$ respectively. Our results showed Pb and Cd average concentration in plant tissues as 0.24–0.65 and 0.030–0.135 $\mu g\ g^{-1}$ respectively. Gisbert *et al.*[7] reported that Pb and Cd limits must be 50–300 and 1–3 mg kg^{-1} according to European Union limits for agricultural soils. In the present study, Pb and Cd levels (5.36–6.57 and 0.37–0.45 mg kg^{-1}) in soil have been determined which are under the European Union limits for agricultural activities. This value is very important for this region since the region is a potential organic farming area.

The accumulations do not occur only as a result of traffic emissions. Plants can accumulate Cd and Pb in their tissues by taking these elements from the lithosphere, hydrosphere or atmosphere[6]. There was no clear relationship between Pb and Cd accumulations and the distance from highways in present study. This may be explained by several factors such as different sources of these metals (lithosphere, hydrosphere or atmosphere), geographycal structure of research area containing high trees in the vicinity of highway, absorbance of these heavy metals by weeds and bushes, expanding the metals by atmospheric deposition in large area and may be, the most significantly, wind directions and wind speed in this area.

Yangun *et al.*[22] found that enrichment coefficients of Pb, Cd, Cu and Zn were bush > tree > herbaceous in lead-zinc mine area in China. They also found that the accumulations of Pb, Cd, Cu and Zn were different in the same plants (tomato and bean).

Jaffer *et al.*[23] investigated lead levels in date palm and tomato near a highway. They found that as distance from highway increased lead contamination decreased. Spellerberg[24] indicated that "above normal traces of heavy metals were recorded in plants up to 150 m from roads". Deroanne-Bovvin *et al.*[25] monitored lead deposition in plants and soil near highways in urban and rural sites in Belgium. They also investigated the efficiency of an experimental green screen for its protection and filtering abilities during seven years. In the present investigations, there was not a clear distance for uncontaminated zone due to traffic in agricultural land.

Rodriguez-Flores and Rodriguez-Castellon[26] studied lead and cadmium levels in soil and plants near highways as well as their correlation with traffic density in Puerto Rico. They found that wind direction affects the distribution of Pb along a transect. Also, they concluded that approximately 33 m distance of a restricted width in both sites of heavily travelled roads must be present for edible crops for human or animal consumption due to accumulation of Pb and Cd.

Wang *et al.*[27] reported the increase of engine speeds would lead to decrease of concentration of metals in engine exhaust. Both research area (Kazova and Gözova) are located in a large area in which the highways also allow high speed of vehicles. This may have caused less metals in the engine exhaust.

Conclusion

The investigations revealed that (1) the research area does not have great level of Pb and Cd accumulation in soils and plants as well which are within the European Union limits for agricultural soils. (2) The same plant (tomato and bean) does not contain the same levels of Pb and Cd. (3) Pb levels in soil and plants were greater than Cd levels. (4) The order of concentration of Pb and Cd was soil > leaves and fruits. (5) The order of concentration levels in tomato and bean was Pb > Cd. (6) Tomato and bean had higher concentrations of Pb and Cd in Gözova area than in Kazova area. (7) Pb and Cd levels in plant samples were also within common ranges. (8) for this reason, the investigated area has a great potential for organic farming. (9) Factors such as wind direction, geographical structure of area, high trees in the vicinity of highway that filter metals and prevent the metal deposition from highways into the plants, absorption of metals by weeds and bushes, different taking up mechanism (lithosphere, hydrosphere or atmosphere), expanding in a large area by atmospheric deposition etc. might have affected the accumulation and movement of metals in the research area.

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